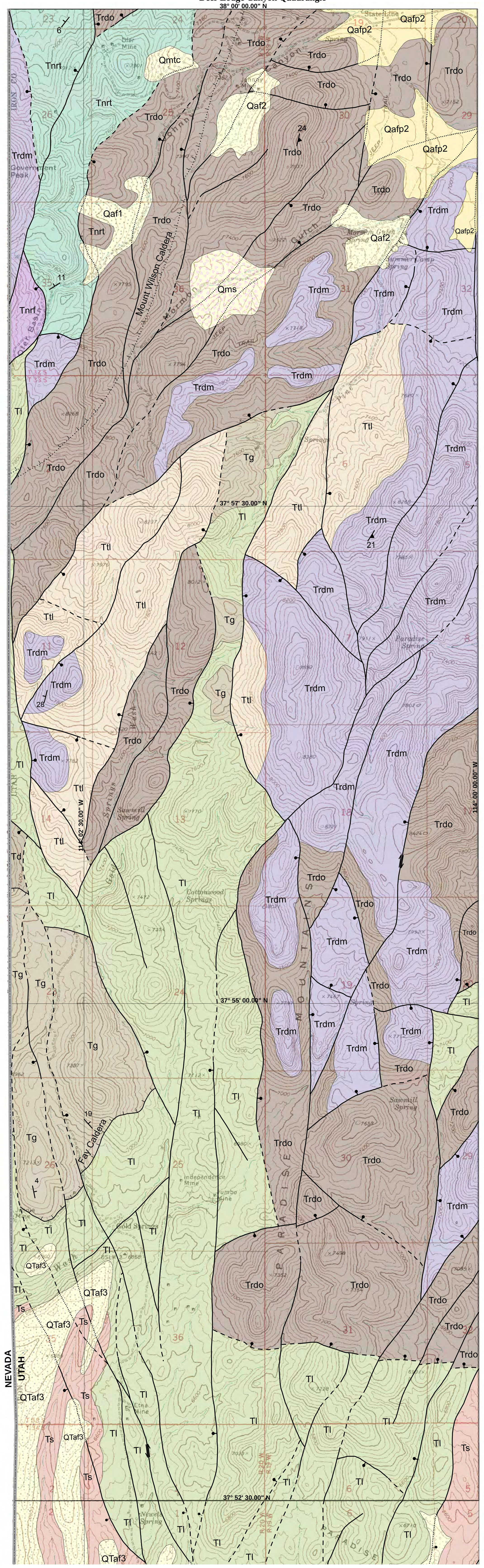
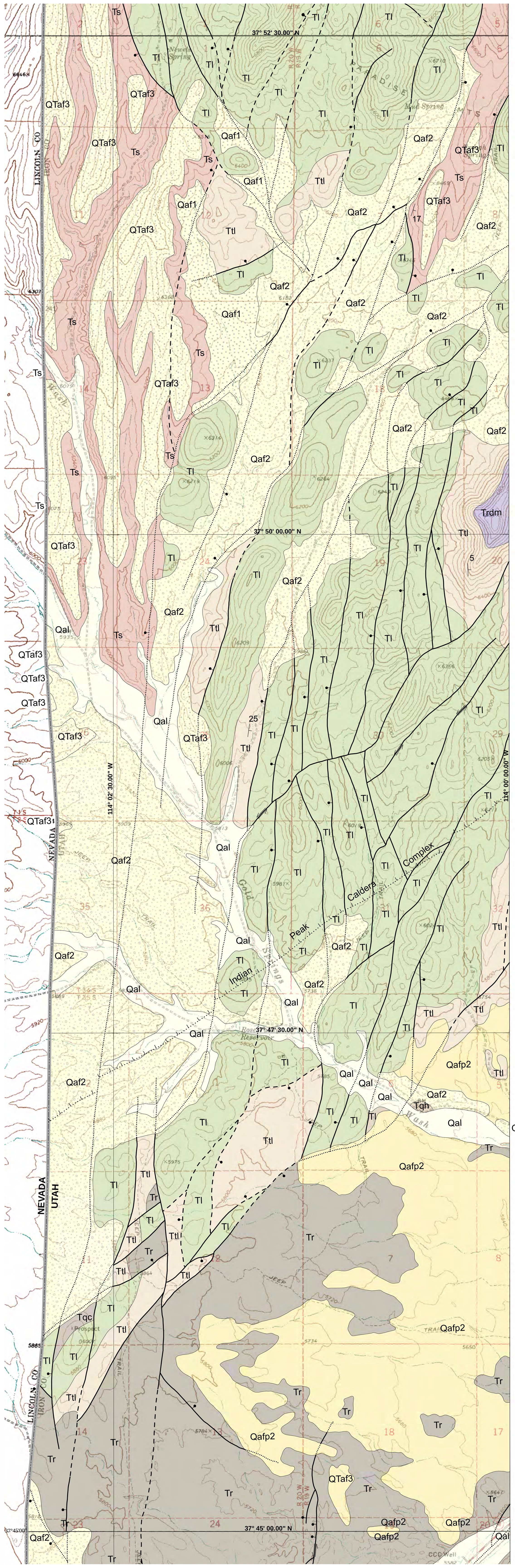
UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources

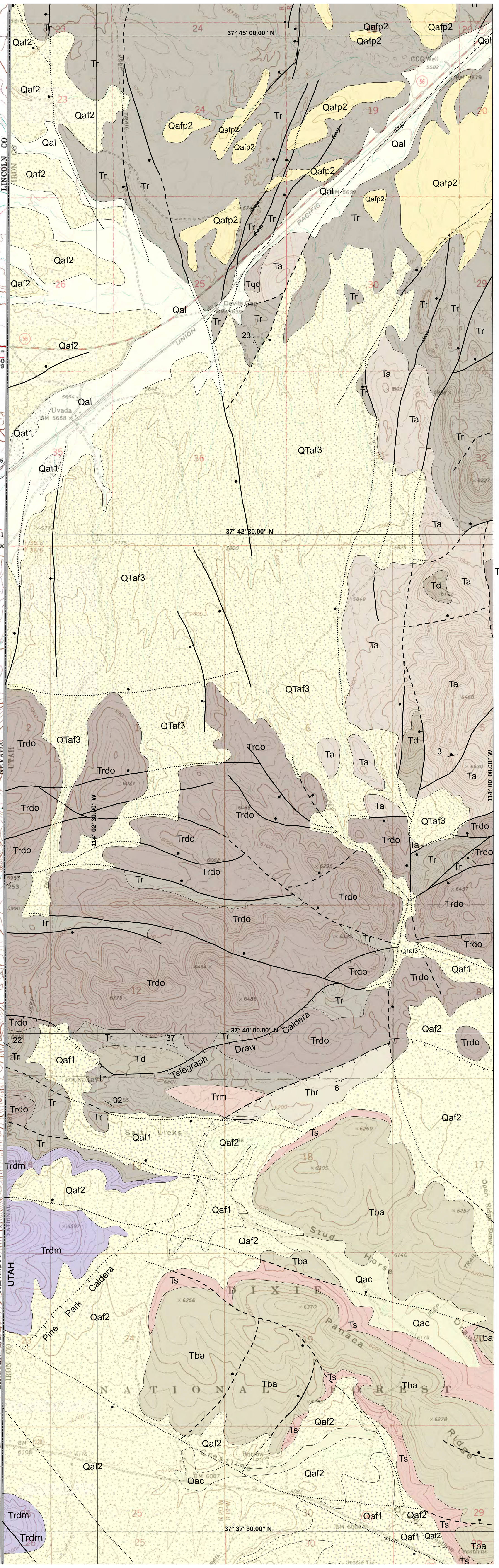
Deer Lodge Canyon Quadrangle



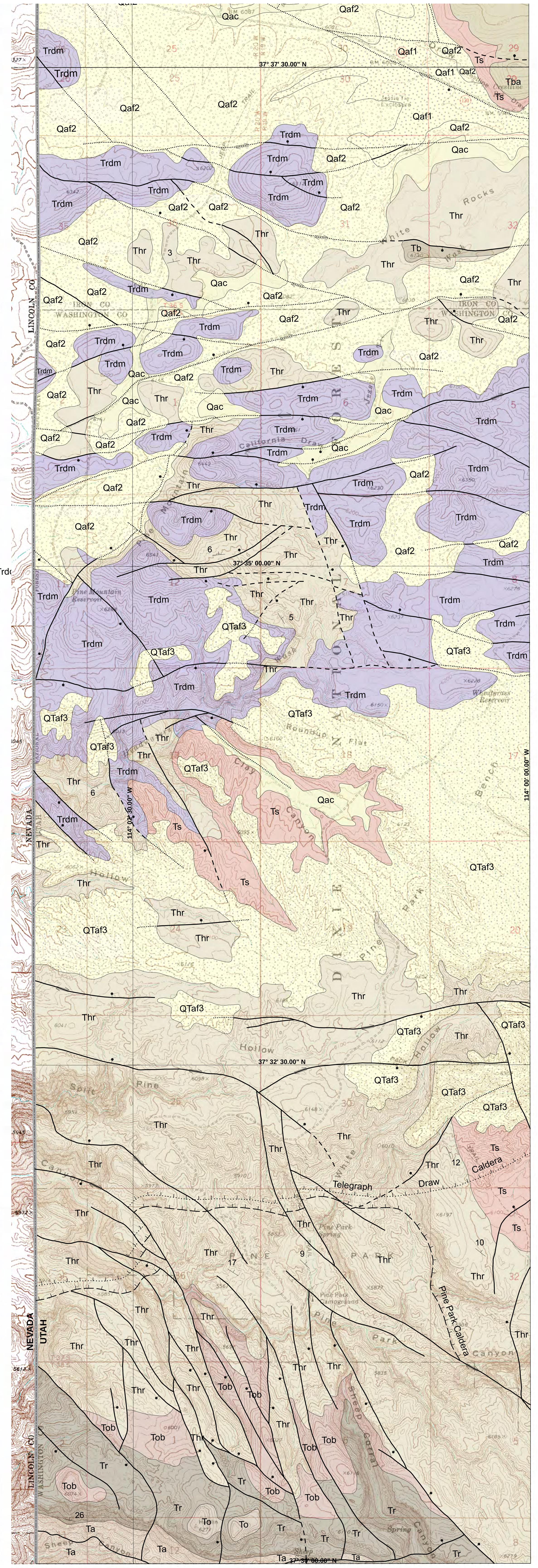
Prohibition Flat Quadrangle



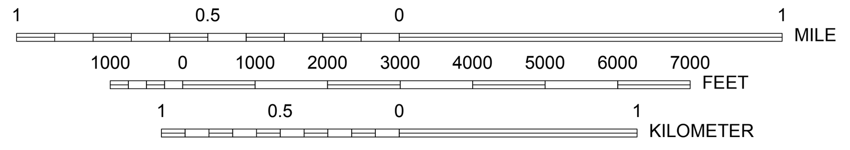
Uvada Quadrangle



Pine Park Quadrangle



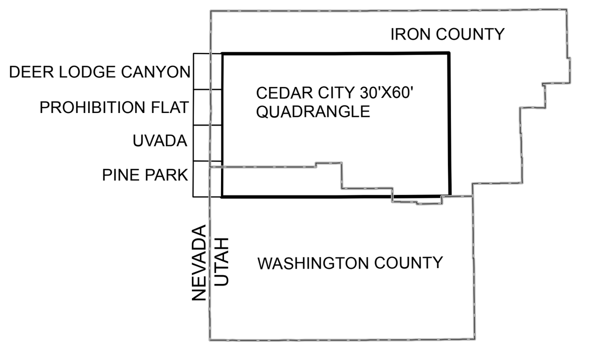
TOPOGRAPHIC CONTOUR INTERVAL 40 FEET
SCALE 1:24,000

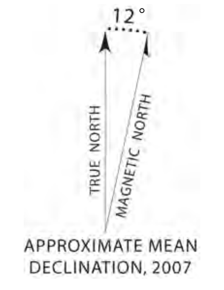


INTERIM GEOLOGIC MAP OF THE UTAH PART OF THE DEER LODGE CANYON, PROHIBITION FLAT, UVADA, AND PINE PARK QUADRANGLES (EAST PART OF THE CALIENTE 30' X 60' QUADRANGLE), IRON AND WASHINGTON COUNTIES, UTAH

By
Peter D. Rowley, David B. Hacker, David J. Maxwell, Joshua D. Maxwell, and Jonathan T. Boswell

2008





APPROXIMATE MEAN DECLINATION, 2007

Base from USGS 7.5' Topographic Quadrangles
Projection: UTM Zone 12
Datum: NAD 1983
Spheroid: Clarke 1886

Project Manager: Bob Biek (UGS)
GIS and Cartography: GIS Services & Consulting, LLC
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This map was created from Geographic Information System (GIS) files using ArcGIS software from ESRI

INTERIM GEOLOGIC MAP OF THE UTAH PART OF THE DEER LODGE CANYON, PROHIBITION FLAT, UVADA, AND PINE PARK QUADRANGLES, (EAST PART OF THE CALIENTE 30′ X 60′ QUADRANGLE), IRON AND WASHINGTON COUNTIES, UTAH

by

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UTAH GEOLOGICAL SURVEY
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DESCRIPTION OF MAP UNITS

Qal **Alluvium** (Holocene)—Youngest alluvium and colluvium in channels, floodplains, and adjacent low terraces of rivers and major streams; sand, silt, and clay with lenses of gravel; maximum thickness about 20 feet (6 m).

Qat_1 **Stream-terrace deposits** (Holocene and late Pleistocene)—Sand and gravel that form dissected surfaces as much as 5 feet (2 m) above the level of adjacent modern streams; mapped only along Sheep Spring Draw near the train stop of Uvada; maximum thickness about 5 feet (2 m).

Qac **Alluvium and colluvium** (Holocene)—Youngest alluvial and colluvial deposits in and near streams in small basins; sand, silt, and clay with lenses of gravel; maximum thickness about 10 feet (3 m).

Qaf_1 **Young alluvial-fan deposits** (Holocene and late Pleistocene)—Poorly to moderately sorted silt, sand, and gravel deposited by streams, sheetwash, debris flows, and flash floods on alluvial fans; includes alluvium and colluvium in upper stream courses; surfaces are modern and generally undissected; maximum thickness at least 30 feet (10 m).

Qaf_2 **Middle alluvial-fan deposits** (late and middle Pleistocene)—Poorly to moderately sorted silt, sand, and gravel deposited by streams, sheetwash, debris flows, and flash floods on alluvial fans; surfaces are moderately dissected by modern streams; maximum thickness at least 50 feet (15 m).

$QTaf_3$ **Old alluvial-fan deposits** (early Pleistocene and Pliocene)—Poorly to moderately sorted silt, sand, and gravel deposited by streams, sheetwash, debris flows, and flash floods on alluvial fans; surfaces are well dissect-ed by modern and older streams; maximum thickness at least 100 feet (30 m).

$Qafp_2$ **Middle piedmont-slope alluvial-fan deposits** (late and middle Pleistocene)—Poorly to moderately sorted silt, sand, and gravel deposited by streams, sheetwash, debris flows, and flash floods on coalesced alluvial fans and pediments; surfaces are moderately dissected by modern streams; maximum thickness at least 20 feet (7 m).

Qmtc **Talus and colluvium** (Holocene to middle Pleistocene)—Poorly sorted, mostly angular gravel, sand, and silt deposited by rockfall, creep, sheetwash, debris flow, and streams along scarps and hillsides; mostly mapped where conceals underlying bedrock; maximum thickness about 30 feet (10 m).

Qms **Landslide deposits** (Holocene to middle Pleistocene)—Unsorted, mostly angular, unstratified rock debris moved by gravity from nearby bedrock cliffs; maximum thickness about 50 feet (15 m).

Ts **Basin-fill sedimentary rocks** (Pliocene and Miocene)—Poorly to moderately consolidated, tan, gray, and light-red, tuffaceous sandstone and subordinate mudstone, siltstone, and conglomerate deposited in basins with an age ranging from Pliocene to about 19 Ma and due to two origins, either extensional faults or calderas; most basins are related to the basin-range episode of regional extension that formed the Basin and Range Province (Christiansen and Lipman, 1972; Rowley, 1998; Rowley and Dixon, 2001); the largest extensional basin in the map area is an apparent graben beneath Prohibition Flat, but small basins locally underlie other downfaulted areas; alternatively, some basins formed during the last subsidence of the Pine Park and Telegraph Draw calderas of the Caliente caldera complex, which is largely in Nevada west of the southern half of the map area but which is also partly in Utah; of these two calderas, the margins of the Pine Park caldera, which erupted the tuff of Honeycomb Rock (Thr), and the Telegraph Draw caldera, which erupted the Racer Canyon Tuff (Tr), cross the map area; south of Enterprise Reservoir, which is 8 miles (13 km) east of the map area, the basin-fill sedimentary rocks that underlie the tuff of Honeycomb Rock contain tracks of Miocene mammals, including apparent mountain lions, camels, coyotes, squirrels, and mice, as well as beetles and other insects (Hunt and Lohrengel, 2006; Reynolds and Milner, 2007); maximum thickness of map unit at least 200 feet (60 m; base not exposed), but considerably thicker east of the mapped area.

Tb **Basalt lava flows** (Miocene)—Resistant, dark-gray and black, vesicular and amygdaloidal, aphanitic and phenocryst-poor lava flow of olivine basalt that is exposed in only one place in the map area, but flows are abundant adjacent to the map area, with ages ranging from about 17 Ma to Quaternary (Rowley and others, 2006; Biek and others, 2007) and therefore are synchronous with basin-range extension (Christiansen and Lipman, 1972; Rowley and Dixon, 2001); the basalt exposures are on one low hill in the northern part of the Pine Park quadrangle; isotopic ages reported for the closest basalt flows to the map area include a basalt flow on Flat Top Mountain 6 miles (10 km) west of Enterprise and 10 miles (16 km) east of the map area, with a K-Ar age of 7.7 $\pm$ 0.2 Ma (Best and others, 1980; Blank, 1993); a flow south of Modena, 4 miles (6 km) east of the map area, with a K-Ar age of 10.8 $\pm$ 0.6 Ma (Best and others, 1980); and a flow east of Beaver Dam Wash State Park and 0.3 miles (0.5 km) west of the map area that yielded $^{40}Ar/^{39}Ar$ ages of 12.29

± 0.07 and 12.06 ± 0.05 Ma (Rowley and others, 2006) that may be younger than indicated because of excess Ar; maximum thickness of lava flows about 30 feet (10 m).

Tba **Basaltic andesite lava flows** (Miocene)—Resistant, medium- and dark-gray, black, and dark-reddish-brown, aphanitic and glassy, phenocryst-poor (generally less than 5 percent plagioclase and minor clinopyroxene, with no recognizable olivine as phenocrysts or in the groundmass) lava flows of apparent basaltic andesite; considered to be from the same extensional tectonic setting as basalt (Tb) but without olivine; a K-Ar age of 11.7 ± 0.6 Ma (Siders, 1991) was determined on tannish-gray, glassy flows that Siders (1991) mapped as basalt just east of the mapped area; this unit extends into the southern Uvada quadrangle and northern Pine Park quadrangle on Panaca Ridge and adjacent hills, where it rests on poorly exposed basin-fill sediments (Ts); a black andesite flow also underlies the tuff of Honeycomb Rock (Thr) in Pine Park Canyon 0.3 miles (0.5 miles) west of Pine Park Campground (now abandoned) in the southern Pine Park quadrangle; a reddish-brown and black basaltic andesite flow lies between the Ox Valley Tuff (locally mapped with the Ox Valley Tuff as unit Tob) and the Racer Canyon Tuff on the northern rim of Sheep Canyon at the southern edge of the Pine Park quadrangle; a 10-foot-wide (3 m) black dike of the same material, interpreted to be the feeder vent, occurs along a west-northwest-striking fault in the northern canyon wall several hundred yards (meters) south of the rim; maximum thickness of these lava flows about 100 feet (30 m).

Trdm **Middle rhyolite and dacite lava flows** (Miocene)—Mostly resistant, gray, pink, tan, and light-purple, thick, widespread sequences of crystal-poor (generally less than 5 percent small phenocrysts of quartz, sanidine, and plagioclase) or aphyric, high-silica rhyolite and perhaps locally dacite volcanic domes and lava flows that erupted from different centers in the mapped area, with isotopic ages of about 15 to 10 Ma; along with basalt (Tb) and basaltic andesite (Tba), the map unit is considered part of the bimodal sequence of volcanism that coincides with regional basin-range extension (Christiansen and Lipman, 1772); no original volcanic landforms survive that might suggest eruptive centers, but centers are assumed beneath the thickest parts of domes; rock is generally flow-foliated and spherulitic, includes flow brecccia, and contains vesicles, lithophysae, and vugs that are lined with vapor-phase minerals; in the Deer Lodge Canyon quadrangle and just east of the map area, includes ash-flow tuff, tuff breccia, bedded water-laid tuff, and other pyroclastic beds, most of which were erupted from the same vents before eruption of the lava flows. In the Uvada and Pine Park quadrangles, map unit commonly overlies the petrographically similar 12-Ma tuff of Honeycomb Rock (Thr) and is interpreted to have been erupted in the caldera source of that tuff, called the Pine Park caldera; in the Deer

Lodge Canyon quadrangle and near the eastern edge of the Prohibition Flat quadrangle, includes the rhyolite lava-flow member of the Steamboat Mountain Formation of Best and others (1987), which has K-Ar and fission-track ages of 13 to 10 Ma; in the Deer Lodge Canyon quadrangle (Williams and others, 1997) and just to the east (Best, 1987), distinction of the map unit from nearby, lithologically similar rhyolite domes and flows of the Blawn Formation (mapped here as old rhyolite and dacite lava flows (Trdo)) is not firm, for it is based on the isotopic ages and on the crystal-poor nature of the map unit, in which biotite is rarely visible in hand specimen (Williams and others, 1997). Just east of the mapped area, in the northern Bull Valley Mountains, voluminous rhyolites of the same age and lithology as the map unit have been mapped as the rhyolite of Beryl Junction (K-Ar age of 10.8 $\pm$ 0.5 Ma, Siders, 1985a, b) and the rhyolite of Pinon Point (K-Ar age of 12.8 $\pm$ 0.6 Ma, Siders, 1985a, 1991; maximum thickness at least 500 feet (150 m), but the base is not exposed.

Ttl **Local ash-flow tuff** (Miocene)—Mostly non-resistant, light-tan, light-yellow, and light-gray, crystal-poor (5 to 10 percent small phenocrysts of quartz and sanidine, with minor to rare plagioclase and biotite), unwelded, rhyolite ash-flow tuff, surge deposits, and minor bedded airfall and water-laid tuff; contains several percent dark crystal-poor, rhyolite lithic fragments and at least 10 percent light-green, light-yellow, and tan pumice; unit represents pyroclastic eruptions that preceded the local lava-flow eruptions from many local centers in the Deer Lodge Canyon and Prohibition Flat quadrangles; mapped by Best (1987) and Williams and others (1997) as a lumped unit (their Tt) or as a tuff member of either the Steamboat Mountain (their Tst) or Blawn (their Tbt) Formations; here lumped and mapped only where the deposits have run out from their source rhyolite eruptive center or where thick, but elsewhere, local ash-flow tuff is thin and poorly exposed so that map scale requires the tuffs to be included within the lava-flow unit (our Trdm or Trdo); age thus has a broad span, from 22 to 10 Ma because individual tuff units are not distinctive or are not found in clear stratigraphic relationships with diagnostic regional ash-flow tuffs; all deposits overlie the latite unit (Tl); maximum thickness at least 300 feet (100 m).

Thr **Tuff of Honeycomb Rock** (Miocene)—Soft, generally light-gray, tan, and light-yellow, unwelded, crystal-poor (about 2 percent sanidine, with traces of quartz and plagioclase), high-silica rhyolite ash-flow tuff and minor tuffaceous sandstone; outflow deposits are intertongued within the basin-fill sedimentary rocks (Ts) east of the map area, as at Honeycomb Rock Campground adjacent to Upper Enterprise Reservoir 8 miles (13 km) east of the mapped area; part of the bimodal sequence of rocks associated with regional extension; most deposits in the map area are inferred to be intracaldera deposits within the Pine Park caldera, named by Siders (1991) and part of the Caliente caldera complex (Rowley and others, 1995, 2006); the margins of the Pine Park caldera are almost nowhere exposed but a small part of the northwestern topographic wall is inferred northwest of Panaca Ridge in the Uvada quadrangle; the main evidence for the caldera is a profound gravity low (Blank and Kucks, 1989; Cook and others, 1989; Bankey and others, 1998), which suggests the presence of a caldera that is about 20 miles (32 km) long east-west and 10 miles (16 km) wide north-south, mostly in Nevada but spanning the state boundary and therefore within and both east and west of the map area, generally between Pine Park, Utah, and northern Beaver Dam State Park, Nevada; map unit overlain in Headwaters Wash by crystal-poor rhyolite lava flows and domes of similar high-silica rhyolite petrology, interpreted to be intracaldera or rim domes from the same source magma chamber and mapped as the middle rhyolite and dacite lava flows (Trdm); pieces of these domes are caught in oblique-slip, west-northwest-striking faults. Three new $^{40}Ar/^{39}Ar$ ages of the unit were given by Rowley and others (2006) and UGS and NMGRL (2007, 2008): (1) an age of 11.91 $\pm$ 0.04 Ma from a sample collected just west of Beaver Dam State Park, just west of the map area; (2) an age of 11.84 $\pm$ 0.05 Ma from a sample collected at Honeycomb Rock Campground; and (3) a preliminary age of 11.95 $\pm$ 0.07 Ma (UGS and NMGRL, 2007) from a sample collected a half mile (0.8 km) north of Pine Park campground, in the map area; thickness at least 1,000 feet (300 m) in and near Headwaters Wash and Pine Park Canyon, in and west of the map area, suggestive of caldera subsidence, but the unit is floored by a thin basaltic andesite flow (Tba) in these canyons, and in turn by the Ox Valley Tuff (To).

Tob **Ox Valley Tuff and basaltic andesite lava flows, undivided** (Miocene)—Moderately resistant, thin, gray and light-red Ox Valley Tuff and underlying red and orange basaltic andesite flows, each about 30 feet (10 m) thick, on and north of the northern rim of Sheep Canyon, in the southern Pine Park quadrangle.

To **Ox Valley Tuff** (Miocene)—Moderately resistant, gray and red, poorly to densely welded, crystal-poor, high-silica rhyolite ash-flow tuff exposed as outflow in the map area; part of the bimodal sequence; unit derived from Mineral Mountain (Biek and others, 2007; Rowley and others, 2007), which is a laccolith and the southern pluton of the Iron Axis, located 5 miles (8 km) south-southeast of the map area. The age of the Ox Valley Tuff was formerly unclear (Rowley and others, 1995), but several new $^{40}Ar/^{39}Ar$ ages suggest that the age is 14.0 to 13.5 Ma (Snee and Rowley, 2000; Rowley and others, 2006; UGS and NMGRL, 2007): (1) a plateau age of 13.46 $\pm$ 0.05 Ma from a sample from Ox Valley, just south of the map area, (2) a plateau age of 14.10 $\pm$ 0.03 Ma from a sample from just west of Beaver Dam State Park, west of the map area, (3) a plateau age of 12.19 ± 0.08 Ma from a sample of a rhyolite flow that rests on the Ox Valley Tuff, from Docs Pass, 5 miles (8 km) southwest of the map area; and (4) a single-crystal fusion age of 13.93 ± 0.08 Ma from Cow Hollow, southwest of Enterprise and 15 miles (24 km) east of the map area; maximum thickness about 50 feet (15 m).

Trdo **Old rhyolite and dacite lava flows** (Miocene)—Mostly resistant, generally gray, red, brown, and tan, locally thick, crystal-poor to crystal-rich (generally 10 to 20 percent phenocrysts of quartz, sanidine, plagioclase, and minor biotite) low-silica rhyolite and perhaps dacite volcanic domes and lava flows erupted from different vents about 22 to 18 Ma; unit probably represents the terminal phase of calc-alkaline volcanism, related to subduction in the West and predating the profound regional extension that formed the Basin and Range province (Lipman and others, 1972; Rowley, 1998; Rowley and Dixon, 2001); map unit locally flow-foliated and spherulitic, includes flow breccia, and may contain vesicles, lithophysae, and vugs that are lined with vapor-phase minerals; in the Deer Lodge Canyon quadrangle and just east of the map area, includes ash-flow tuff, tuff breccia, bedded water-laid tuff, and other pyroclastic beds, most of which were erupted from the same vents before eruption of the lava flows; in the Uvada quadrangle, overlies or inferred to overlie the Racer Canyon Tuff; some of these flows and domes are crystal-rich and petrographically and chemically identical to the Racer Canyon Tuff, indicating that they were derived from the same magma chamber, as recognized by Siders (1991) from her mapping just east of the map area, where she called them the rhyolitic lava flow member of the Racer Canyon Tuff; in the Deer Lodge Canyon quadrangle, map unit includes the rhyolite flow member of the Blawn Formation of Best and others (1987), which has K-Ar and fission-track ages of 23 to 18 Ma from samples collected in and north of the map area; in the Deer Lodge Canyon quadrangle (Williams and others, 1997) and just to the east (Best, 1987), distinction of the map unit from nearby, lithologically similar rhyolite domes and flows of the Steamboat Mountain Formation, mapped here as the middle rhyolite and dacite lava flows (Trdm), is not firm, for it is based on the isotopic ages and on the more crystal-rich nature of the map unit, in which biotite is generally visible in hand specimen (Williams and others, 1997); thickness of individual units as much as 600 feet (200 m). The part of the map area in the Deer Lodge Canyon quadrangle, and areas just to the west, contain the State Line, Fay, Gold Springs, and Deer Lodge mining districts, which produced mostly gold and silver from the late 1800s through World War II (Perry, 1976; Thomson and Perry, 1976; Collins, 1977; Keith, 1980; Williams and others, 1997); in largest part, the metals are in mostly north-northwest- to north-northeast-striking quartz-calcite-adularia veins that fall along or close to large basin-range faults mapped here; the main host for these veins is the map unit (Trdo), although some productive veins are also in some of still older map units, particularly the latitic lava flows (Tl) and the Ripgut Formation (Tnrf, Tnrt); all mining districts are within the buried Indian Peak caldera complex, perhaps the World's largest; this presence suggests that the long magmatism that resulted in and followed Indian Peak eruptions localized the metals, and that at least 5 million years later they were remobilized and carried upward during rhyolite (Trdo) magmatism and subsequent basin-range faulting.

Ta **Andesite lava flows** (Miocene)—Moderately resistant, red and brown, locally thick, crystal-poor and crystal-rich andesitic lava flows, flow breccia, and mudflow breccia erupted from scattered stratovolcanoes or other local vents in the Uvada and Pine Park quadrangles between 23 and 21 Ma, and perhaps younger; andesite occurs at many stratigraphic positions in this age range east and south of the map area, and to the south (Biek and others, 2007; Rowley and others, 2007) formed sequences several thousands of feet thick; in the Uvada quadrangle, crystal-rich andesite (30 percent phenocrysts of mostly plagioclase, subordinate clinopyroxene, and minor hornblende, biotite, and Fe-Ti oxides) about 60 feet (20 m) thick overlies the Bauers Member of the Condor Canyon Formation south of the railroad tracks at Devils Gap; Best (1987) mapped hornblende andesite north of Modena and just east of the map area that he measured at about 1,500 feet (500 m) thick and considered to perhaps overlie the Bauers Member; about a half mile (0.8 km) southeast of the Devils Gap occurrence, a petrologically different but similarly crystal-rich (30 to 35 percent phenocrysts of mostly plagioclase and subordinate to minor clinopyroxene, hornblende, biotite, olivine, and Fe-Ti oxides) andesite is exposed beneath the Racer Canyon Tuff (with the dacite unit between the two still farther south) and is at least 200 feet (60 m) thick; this latter unit was described by Siders (1991) just to the east, who thought that it was perhaps 24 Ma, but this seems to be based on an erroneous K-Ar age, for the andesite was considered by Blank (1993) to be correlated with the andesite of Shoal Creek northwest of Enterprise, which is underlain by a regional ash-flow tuff, the 22-Ma Rencher Formation, and has $^{40}Ar/^{39}Ar$ ages of 21.07 $\pm$ 0.05 and 20.51 $\pm$ 0.08 Ma (Rowley and others, 2006, Table 2; UGS and NMGRL, 2008); at the southern margin of the Pine Park quadrangle, on the northern wall of Sheep Canyon, nonresistant, tan, gray, and pink volcanic mudflow breccia of crystal-poor (10 to 15 percent phenocrysts of plagioclase and subordinate hornblende, biotite, clinopyroxene, and Fe-Ti oxides) andesite about 200 feet thick (60 m) underlies the Racer Canyon Tuff; south of that, and south of a fault that contains a dike of basaltic andesite (see unit Tba), similar volcanic mudflow breccia in the lower part of the northern wall and making up part of the southern wall of Sheep Canyon contains a component of sand eroded from the Racer

Canyon Tuff and was erroneously interpreted by Rowley and others (2007), before the current mapping, to be caldera megabreccia; these outcrops are now interpreted to be the product of erosion of the Racer Canyon Tuff during continued post-tuff andesite eruption, and are now in the downthrown block of the fault.

Racer Canyon Tuff (Miocene)

Tr T**uff—**Resistant, tan, gray, and pink, poorly to moderately welded, low-silica rhyolite ash-flow tuff; where exposed in the southern Prohibition Flat, northern half of the Uvada quadrangle, and southern Pine Park quadrangles, is interpreted to be outflow tuff; however, the exposures in the southern Uvada quadrangle are interpreted to be intracaldera tuff on the basis of three lines of evidence: (1) just east of the southern Uvada quadrangle, north of Telegraph Draw, the Racer Canyon Tuff contains pumice blocks as large as 2 feet (0.6 m) in diameter and large abundant phenocrysts, suggestive of proximity to its source caldera (Rowley and others, 1995, 2006); (2) in the upper drainage basin of Telegraph Draw just east of the map area and continuing west across the map area of the south-central Uvada quadrangle, Siders (1991) mapped a crystal-rich rhyolite dome (her rhyolitic lava flow member of the Racer Canyon Tuff; mapped here with the old rhyolite and dacite lava flows, unit Trdo) that overlies and is identical in petrography and chemistry to the Racer Canyon Tuff and here interpreted to be a dome erupted on the rim of, and perhaps partly in, the caldera following eruption of the map unit; and, best of all, (3) our discovery just south of upper Telegraph Draw (NE1/4 section 17, T.36 S., R.19 W., about 0.35 miles (0.56 km) east of the boundary of the map area, of a caldera megabreccia mass about 0.1 mile (0.16 km) long of reddish-brown, crystal-rich dacite surrounded by Racer Canyon Tuff whose base is not exposed; the caldera source of the Racer Canyon Tuff is here named the Telegraph Draw caldera of the Caliente caldera complex. In addition, the proximity of the Telegraphy Draw caldera to the Pine Park caldera, the source of the tuff of Honeycomb Rock (Thr), suggests that the large gravity anomaly shown by Blank and Kucks (1989) is partly due to the Telegraph Draw caldera and that the two calderas largely coincide with each other; south of Upper Enterprise Reservoir, about 7 miles (11 km) east of the map area, where we infer the buried southern margin of the two calderas to be in the southern Pine Park quadrangle, at least 12 outflow cooling units of the Racer Canyon Tuff that have a total thickness of 1,500 feet (450 m) are well exposed, also suggestive of nearness to its source (Rowley and others, 1995, 2006). The exact age of the Racer Canyon Tuff has long been unclear, in part because it has been difficult to distinguish it from the nearly synchronous and petrologically and chemically similar Hiko Tuff, derived from the Delamar caldera at the opposite (western) end of the Caliente caldera complex (Rowley and others, 1995); four older K-

Ar and lead-alpha ages summarized by Siders and others (1990) gave an average of 19.4 Ma; Rowley and others (1995, 2006) gave an estimate of 18.7 Ma based on two $^{40}Ar/^{39}Ar$ ages from sample 89-314e (Rowley and others, 2006), one a plateau age of 18.70 ± 0.11 and the other a total-gas age of 18.63 ± 0.03 Ma; an $^{40}Ar/^{39}Ar$ plateau age of 17.10 ± 0.03 Ma from sample 92-971a (Rowley and others, 2006), however, is too young; Gromme and others (1997) applied paleomagnetism and additional argon geochronometry to determine that the Racer Canyon Tuff is slightly older than the Hiko Tuff and has an $^{40}Ar/^{39}Ar$ age of 18.33 ± 0.03 Ma; the map unit, as well as the older units listed below, clearly belong to the calc-alkaline assemblage, formed during regional subduction of the eastern Pacific Ocean basin beneath Western North America (Lipman and others, 1972); maximum exposed thickness in the area is 400 feet (120 m) but the unit likely is much thicker in its buried caldera.

Trm **Megabreccia—**Moderately resistant, reddish-brown, slightly hydrothermally altered breccias made up of the dacite lava flows (Td) that are exposed just to the north, on the rim of the telegraph Draw caldera; although the unit is not well exposed, breccias clasts are at least several yards (meters) long; two masses were found, the larger one (0.6 miles, 1 km long) just north of the Salt Licks (N1/2 section 13, T. 36 S., R. 20 W.) in the map area (southern Uvada quadrangle); the smaller mass, just east of the map area, was mapped by Siders (1991) and Rowley and others (2006) as Racer Canyon Tuff; the megabreccia mass is interpreted to have formed by landsliding of dacite bedrock (unit Td) off the northern topographic wall of the Telegraph Draw caldera southward into the caldera due to oversteepening of the wall because of vertical subsidence of the caldera following Racer Canyon Tuff ash-flow tuff eruptions; maximum exposed thickness of each mass is about 30 feet (10 m), although neither base is exposed.

Tg **Tuff of Gold Springs** (Miocene)**—**Resistant to non-resistant, light-gray, light-purple, pink, and tan, crystal-poor (10 to 20 percent phenocrysts of subequal amounts of quartz and sanidine, with trace amounts of plagioclase and altered ferromagnesian minerals), unwelded to moderately welded, rhyolite ash-flow tuff; contains 1 to 10 percent partly compacted pumice and sparse dark-gray, rhyolite lithic fragments; unit named and mapped by Williams and others (1997), who also mapped its source, the "Gold Springs depression," which they interpreted to be a funnel-shaped vent, elliptical (elongated northwest) in plan view, with a maximum diameter of 1.75 mile (2.8 km), partly extending west of the map area; we consider, however, most walls to be vertical to outward sloping, find most beds in the source to be dipping only gently, and interpret it to be a small caldera, which subsided vertically following eruption of the tuff; we call it the Fay caldera, after the gold-mining ghost town (now only a single one-room log cabin and a cemetary remain) in Nevada, just west of the caldera; our mapping shows the caldera to be more circular in plan view than Williams and others (1997) showed, as well as being slightly larger (about 2 miles, 3.2 km), and to be cut by north-striking basin-range faults; Williams and others (1997) also mapped a small intracaldera intrusion, whose eastern edge is about 300 feet (100 m) west of the map boundary; the intrusion is in part a breccia pipe and is of the same petrology as the tuff; intracaldera tuff, in contrast to outflow tuff, is commonly densely welded and locally hydrothermally altered and mineralized; intracaldera tuff is overlain by a 60-foot (20-m) thick, subhorizontal, resistant, purplish-gray, rhyolite lava flow (mapped by Williams and others [1997] as the rhyolite flow member of the Steamboat Mountain Formation) that has the same petrography as the tuff and that we have included as a cogenetic intracaldera flow, not separated from the intracaldera tuff fill in our mapping; the age of the tuff of Gold Springs is poorly constrained: it was considered a member of the Blawn Formation by Williams and others (1997) based on its lithology; it must be younger than the 21.0-Ma-dacite (Td) because the caldera cuts the dacite (Williams and others, 1997), and the tuff of Gold Springs must predate the intracaldera intrusion, which yielded an age of 16.5 $\pm$ 1.1 Ma (Keith, 1980); outflow tuff to the north of the caldera is as much as 250 feet (75 m) thick, whereas the intracaldera fill is more than 600 feet (200 m) thick, with its base not exposed. Mines of the former Gold Springs and Fay mining districts surround the Fay caldera, some along the topographic caldera margin (Perry, 1976; Williams and others, 1997); some others are controlled by the intracaldera intrusion, which contains a fluorite pipe; most of the mineral veins in the districts, however, strike north-northwest, parallel to the major basin-range faults here.

Td **Dacite lava flows** (Miocene)—Resistant, light-gray, light-purple, reddish-tan, and locally dark-green, crystal-rich dacitic lava flows and flow breccia, in places with basal glass, from several widely scattered places in the map area; in the Deer Lodge Canyon quadrangle, consists of flows 350 feet (110 m) thick mapped by Williams and others (1997) as the lava-flow member of the intermediate-composition rocks of Serviceberry Canyon, containing 25 percent phenocrysts of plagioclase and sanidine, with minor biotite, augite, Fe-Ti oxides, and quartz, and having yielded a K-Ar age of 21.0 $\pm$ 1.3 Ma from a sample collected from an intrusive phase just west of the map area (Keith, 1980); in the Uvada quadrangle, a small patch of medium-gray flows about 60 feet (20 m) thick and 2.25 miles (3.6 km) southeast of the railroad siding of Uvada is part of a larger series of flows just to the east, which were mapped as dacite by Siders (1991), containing 30 to 35 percent large phenocrysts of mostly plagioclase, with subordinate hornblende, biotite, and clinopyroxene, and minor Fe-Ti oxides and quartz, and correlated with dacite for which Siders (1985a) obtained a K-Ar age of 21.7 ± 3.3 Ma; farther south, about 1 mile (1.6 km) north of the western end of Panaca Ridge, the same gray and medium-tan lava flows and volcanic mudflow breccia are at least 100 feet (30 m) thick and underlie outflow Racer Canyon Tuff at the edge of its source Telegraph Draw caldera, from where it shed landslides (megabreccia) into the caldera.

Quichapa Group (Miocene and Oligocene)—Regional ash-flow sheets (Mackin, 1960; Williams, 1967; Anderson and Rowley, 1975).

Tqh **Harmony Hills Tuff** (Miocene)—Resistant, gray and tan, crystal-rich, moderately welded, dacitic ash-flow tuff; source unknown but isopachs are centered on Bull Valley, 20 miles (32 km) east-southeast of the map area, in the eastern Bull Valley Mountains (Blank, 1959; Williams, 1967; Rowley and others, 1995); exposed only in two small faulted outcrops south of Gold Springs Wash, in the southern Prohibition Flat quadrangle; map unit has an $^{40}Ar/^{39}Ar$ plateau age of 22.03 ± 0.15 Ma (Cornell and others, 2001); maximum thickness about 30 feet (10 m).

Tqc **Condor Canyon Formation** (Miocene)—Resistant, brown, gray, and purple, crystal-poor, densely welded, dacitic to trachydacitic ash-flow tuff of two eruptive sequences, the Bauers Tuff Member and the underlying Swett Tuff Member, both derived from the northwestern part (Clover Creek caldera) of the Caliente caldera complex (Rowley and others, 1995); only the Bauers Member is exposed in the map area, south of Gold Springs Wash, in the southern Prohibition Flat quadrangle; age of the Bauers Member is 22.8 Ma based on $^{40}Ar/^{39}Ar$ ages by both Best and others (1989a) and Rowley and others (1994); maximum thickness about 100 feet (30 m).

Tl **Latitic lava flows** (Miocene)—Resistant, reddish-brown and brown, crystal-poor to crystal-rich (10 to 30 percent plagioclase and subordinate to minor biotite, clinopyroxene, hornblende, and Fe-Ti oxides) latite or dacite lava flows and minor flow breccia and mudflow breccia that are widespread in the Deer Lodge Canyon and Prohibition Flat quadrangles (Williams and others, 1997), as well as north of Modena, just east of the map area (Best, 1987); flows locally have dark-gray basal vitrophyres and contain vesicles and gas cavities as large as 1 inch (2.5 cm); unit has K-Ar ages of 22.8 ± 0.9 and 21.9 ± 0.8 Ma (Best, 1987) and is a host for many mineralized veins; maximum thickness about 1,000 feet (300 m).

Needles Range Group (Oligocene)—Regional ash-flow sheets and lava flows derived from the Indian Peak caldera complex, which is centered on the Utah-Nevada State line north of the map area (Best and others, 1989a, b; Williams and others, 1997); no margins of the caldera complex are exposed in the map area, but its buried southern margin passes through the southern Prohibition Flat quadrangle (Williams and others, 1997); in addition, the buried southern margin of the Mount Wilson caldera of the Indian Peak caldera complex passes through the northern Deer Lodge Canyon quadrangle (Williams and others, 1997).

Ripgut Formation—Mostly resistant, crystal-poor (5 to 10 percent phenocrysts of quartz, sanidine, and plagioclase), rhyolite ash-flow tuffs and lava flows with identical mineralogy; probably intracaldera deposits, derived from and deposited in the Mount Wilson caldera (Williams and others, 1997) and likely to be much thicker than the exposed thickness; mapped only in the northern Deer Lodge Canyon quadrangle, where the rocks are separated into ash-flow tuffs and overlying lava flows; unit not isotopically dated but its age is well constrained because it is sandwiched between the overlying Isom Formation (about 27 Ma) and the underlying Lund Formation (27.9 Ma) of the Needles Range Group (Best and Grant, 1987; Best and others, 1989a, b); map unit is a host for mineralized veins.

Tnrf **Lava flows—**Moderately resistant, light-gray and light-green lava flows; maximum exposed thickness about 200 feet (60 m), with its base not exposed.

Tnrt **Ash-flow tuff—**Resistant, light-gray and tan, moderately welded ash-flow tuff in which white collapsed pumice fragments are conspicuous and abundant (at least 10 percent by volume); maximum exposed thickness about 300 feet (100 m), with its base not exposed.

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We much appreciate the help of Grant Willis and Bob Biek of the UGS for assistance on stratigraphic and structural problems and for technical reviews of the manuscript.

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GEOLOGIC SYMBOLS

CONTACT

NORMAL FAULT

Dashed where location inferred; dotted where concealed; bar and ball on downthrown side

OBLIQUE-SLIP FAULT

Dashed where location inferred; dotted where concealed; bar and ball on downthrown side and arrows show relative movement on map

FAY CALDERA

TOPOGRAPHIC MARGIN OF CALDERA: Caldera and caldera complex names shown on the inner side of the caldera margin; Pine Park Caldera, Telegraph Draw caldera, Fay caldera, Mount Wilson caldera, and Indian Peak caldera complex; dashed where location inferred; dotted where concealed; hachures on downthrown side

STRIKE AND DIP BEDDING 26

inclined

STRIKE AND DIP FLOW FOLIATION 5

inclined

MINE

Gold, silver, and base-metal mines in the Stateline, Deer Lodge, Gold Springs, and eastern Deer Lodge mining districts

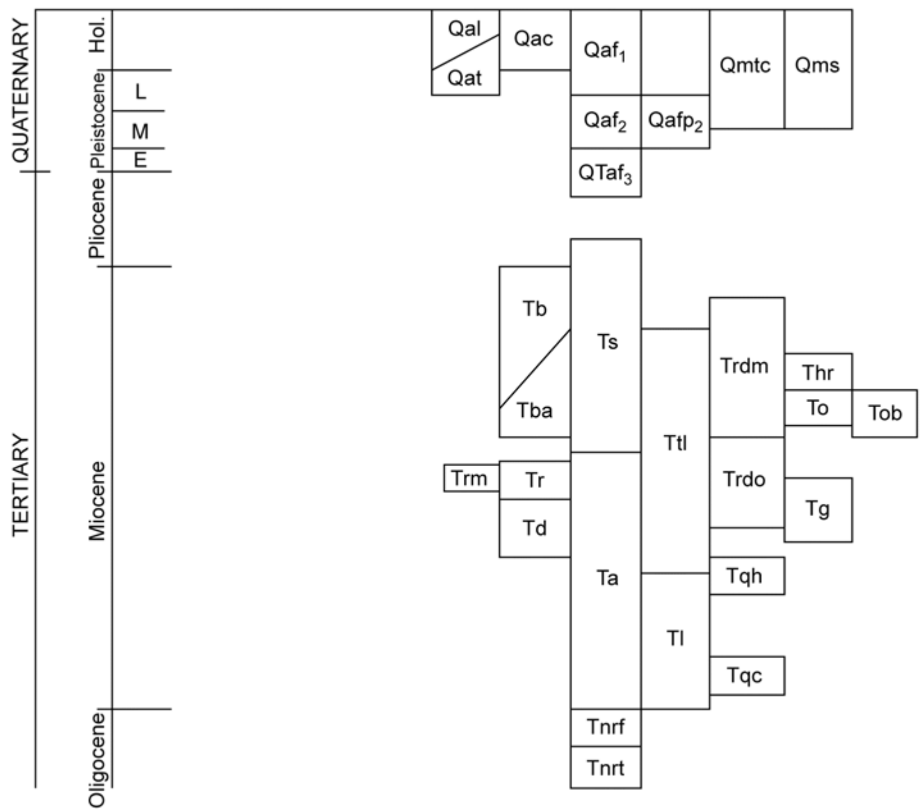
GRAVEL PIT

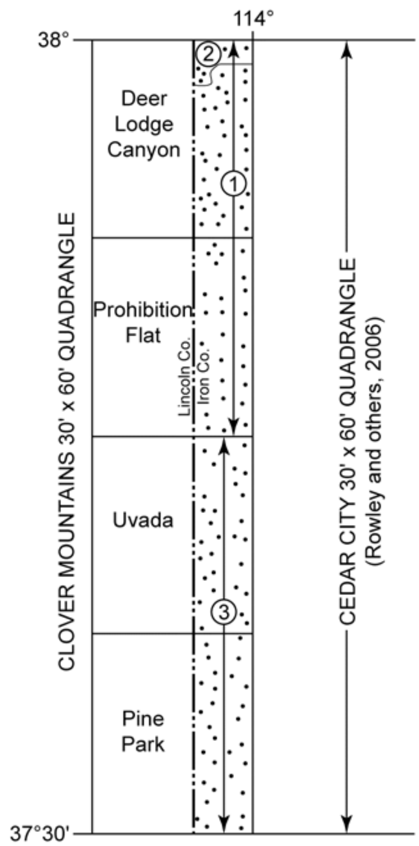
LITHOLOGIC COLUMN

EAST PART OF CALIENTE 30 x 60' QUADRANGLE

Age: Ma	Age: System	Age: Series & Stage	Map Unit	Map Symbol	Thickness: feet	Thickness: meters	Notes
	Quaternary	Holocene & Pleistocene	surficial deposits	various Q, QT			
1.8	Tertiary	Pliocene					
5.3	Tertiary	Pliocene	basin-fill sedimentary rocks	Ts	200+	60+	
	Tertiary	Miocene	basalt lava flows	Tb	30	10	8 to 12 Ma
	Tertiary	Miocene	basaltic andesite lava flows	Tba	100	30	11.7 Ma
	Tertiary	Miocene	middle rhyolite and dacite lava flows	Trdm	500	150	10 to 15 Ma
	Tertiary	Miocene	local ash-flow tuff	Ttl	300	100	
	Tertiary	Miocene	Tuff of Honeycomb Rock	Thr	1000	300	12.0 Ma From Pine Park caldera
	Tertiary	Miocene	Ox Valley Tuff	To	50	15	14.0 to 13.5 Ma
	Tertiary	Miocene	old rhyolite and dacite lava flows	Trdo	600	200	22 to 18 Ma Host for gold and silver mines in 4 mining districts
	Tertiary	Miocene	andesite lava flows	Ta	200+	60+	
	Tertiary	Miocene	Racer Canyon Tuff	Tr, Trm	400+	120+	18.33 Ma From Telegraph Draw caldera
	Tertiary	Miocene	Tuff of Gold Springs	Tg	600+	200+	From Fay caldera, which controlled some gold and silver veins
	Tertiary	Miocene	dacite lava flows	Td	350	110	21.0 Ma
	Tertiary	Miocene	Quichapa Group: Harmony Hills T.	Tqh	30	10	22.0 Ma
	Tertiary	Miocene	Quichapa Group: Condor Can. Fm.	Tqc	100	30	22.8 Ma
	Tertiary	Miocene	latitic lava flows	Tl	1000	300	22.8 to 21.9 Ma Host for gold and silver veins
23.0	Tertiary	Oligocene	Needles Range Group: Ripgut Formation: lava flows	Tnrf	200+	60+	27.9 to 27 Ma From Mount Wilson caldera
	Tertiary	Oligocene	Needles Range Group: Ripgut Formation: ash-flow tuff	Tnrt	300+	100+	Host for gold and silver veins

EAST PART OF THE CALIENTE 30' x 60' QUADRANGLE





PRINCIPAL SOURCES OF GEOLOGIC MAPPING